The Relational Model

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Notes

Review: Network and Hierarchical Models

Idea

Structural information is encoded implicitly using pointers.

Consequences:

- difficult to separate conceptual and physical schemas
- queries must explicitly navigate the data graph ⇒ *procedural* queries
- *procedural* (not *semantic*) specification of integrity constraints

Notes

The Relational Model

Idea

All information is organized in (flat) relations.

Features:

- simple and clean data model
- powerful and *declarative* query/update languages
- semantic integrity constraints
- data independence

Notes

The Relational Model: Formal Definition

Universe
- a set of atomic values $\mathbf{D}$ with equality $(=)$

Domain
- a name D with a set of values $\mathtt{dom}(D) \subseteq \mathbf{D}$

Relation
- **schema:** $R(A_1 : D_1, A_2 : D_2, \ldots, A_k : D_k)$ with
  - name R
  - $A_1, \ldots, A_k$ a set of distinct attribute names
  - $D_1, \ldots, D_k$ a collection of (not necessarily distinct) domain names
- **instance:** a finite relation $\mathbf{R} \subseteq \mathtt{dom}(D_1) \times \cdots \times \mathtt{dom}(D_k)$.

Database
- **schema:** finite set of uniquely-named relation schemas
- **instance:** a relation $\mathbf{R_i}$ for each R_i

Note
- **Intention of a relation:** *The associated relation schema.*
- **Extension of a relation:** *The associated set of tuples.*

Notes

The Relational Model: Properties

Note

- *Relational schemas have named and typed attributes*
- *Relational instances are finite*

Properties of a relation:

1. Based on (finite) set theory
   - Attribute ordering: not strictly necessary
   - Value oriented: tuples identified by attribute values
   - Instance has *set semantics*:
     - No ordering among tuples
     - No duplicate tuples
2. All attribute values are atomic
3. Degree (arity) = # of attributes in schema
4. Cardinality = # of tuples in instance

Notes

Example: A Bibliography Database

Database schema:

```
author(aid:int, name:string)
wrote(author:int, publication:int)
publication(pubid:int, title:string)
book(pubid, publisher, year)
journal(pubid, volume, no, year)
proceedings(pubid, year)
article(pubid, crossref, startpage, endpage)
```

Note

Relational schemas are sometimes abbreviated by omitting the attribute domains.

Notes

Example: A Bibliography Database

Sample database instance:

$$\begin{array}{rclll}
\textbf{author} & = & \{ & (1,\text{John}),(2,\text{Sue}) & \} \\
\textbf{wrote} & = & \{ & (1,1),(1,4),(2,3) & \} \\
\textbf{publication} & = & \{ & (1,\text{Mathematical Logic}), & \\
 & & & (3,\text{Trans. Databases}), & \\
 & & & (2,\text{Principles of DB Syst.}), & \\
 & & & (4,\text{Query Languages}) & \} \\
\textbf{book} & = & \{ & (1,\text{AMS},1990) & \} \\
\textbf{journal} & = & \{ & (3,35,1,1990) & \} \\
\textbf{proceedings} & = & \{ & (2,1995) & \} \\
\textbf{article} & = & \{ & (4,2,30,41) & \}
\end{array}$$

Notes

Example: A Bibliography Database

Sample database instance (tabular form):

`author`

aid	name
1	John
2	Sue

`wrote`

author	publication
1	1
1	4
2	3

`publication`

pubid	title
1	Mathematical Logic
3	Trans. Databases
2	Principles of DB Syst.
4	Query Languages

Notes

Relations vs. SQL Tables

Note

The standard language for interfacing with relational DBMSs is Structured Query Language (SQL). Unfortunately, there are a few important differences between the Relational Model and the data model used by SQL (and relational DBMSs).

Discrepencies between Relational Model and SQL:

1. Semantics of Instances
   - Relations are sets of tuples
   - Tables are multisets (bags) of tuples
2. *Unknown* values
   - SQL data model defines a particular value **null** (intended to mean "unknown") which has some special properties (requires *three-value logic*)

Notes

Integrity Constraints

A relational schema captures only the structure of relations

Idea

Extend relational/database schema with rules called constraints. An instance is only valid if it satisfies all schema constraints.

Reasons to use constraints:

1. Ensure data entry/modification respects database design
   - Shift responsibility from applications to DBMS
2. Protect data from bugs in applications

Notes

Types of Integrity Constraints

- Tuple-level
  - Domain restrictions
  - Attribute comparisons
- Relation-level
  - Key constraints
    - Superkey: a set of attributes for which no pair of distinct tuples in the relation will ever agree on the corresponding values
    - Candidate key: a minimal superkey (a minimal set of attributes that uniquely identifies a tuple)
    - Primary key: a designated candidate key
  - Functional dependencies, etc.

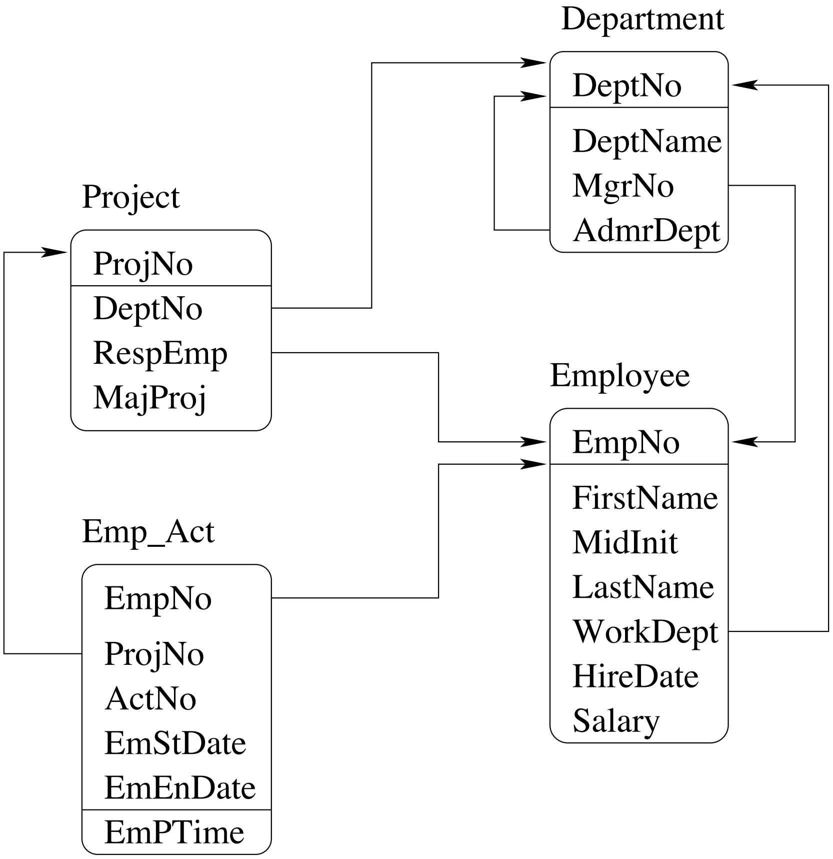
Notes

Types of Integrity Constraints (cont'd)

- Database-level
  - Referential integrity
    - Foreign key: Primary key of one relation appearing as attributes of another relation.
    - Referential integrity: A tuple with a non-null value for a foreign key that does not match the primary key value of a tuple in the referenced relation is not allowed.
  - Inclusion dependencies

Notes

Example: Database Schema showing ICs



Notes